22CS802   **Topics in deep learning**   **4-0-0-4**

Course Overview
The object of the course is to give a first level of introduction to deep learning and also hands-on experience with the more commonly used deep learning techniques using TensorFlow and Keras libraries. At the end of the course, the student will have a good understanding of the various kinds of deep learning techniques, and what kind of deep learning techniques to use under what circumstances. This course is being offered specifically to the students in PhD. The course is offered for 4 credits, with two classes of theory, and one of practicals.

Course Outcomes

COs	Description
CO1	Be able to design, train, deploy neural networks for solving different practi-cal/engineering problems and analyse and report its efficacy
CO2	Have a good level of knowledge (Both Conceptual and Mathematical) on different neural network settings to pursue Research in this Field
CO3	Build skills in using established ML tools/libraries and in building self-learning skills in the field

Course Syllabus
1) Introduction to deep learning
Examples of deep learning
Tasks of deep learning
Difference between traditional learning and deep learning
Deep learning intuition

2) Mathematics basics needed
Gradient descent method
Probabilistic distributions – continuous and discrete
Maximum likelihood

3) Introduction to neural networks
Cost functions, hypotheses and tasks

Training data
Maximum likelihood based cost, cross entropy, mean square error

4) Feed-forward networks and perceptrons
Neuroscience inspiration

5) Learning in neural networks
Output vs hidden layers
Linear vs non-linear networks

6) Backpropagation
Learning via gradient descent
recursive chain rule
bias variance trade off
regularisation

7) Output units – linear, softmax
Hidden units – tanh, RELU, etc
Optimisation algorithms, dropout, batch normalisation

8) Convolutional neural networks (CNNs)
Structure of CNNs
Learning in CNNs
Tuning CNNs
Specific advantages and disadvantages of CNNs

9) Autoencoders
Structure, learning, tuning and specific advantages and disadvantages

10) Generative adversarial networks (GANs)
Intuition behind them
Structure and learning
Utility and disadvantages

11) Recurrent neural networks (RNNs)
Intuition, various types of RNNs
Sequence modelling
Bidirectional RNNs

12) Reinforcement learning (RL)
Overview of RL
Policy gradient
Actor-critic, Q-learning

13) Graph neural networks
Overview of graph neural networks
Principles of GNNs
Working of GNNs

The lab part will be based on TensorFlow 2.

Reference books
Ian Goodfellow, Yoshua Bengio, and Aaron Courville, ``Deep Learning'', MIT Press

Richard Sutton, and Andrew Barto, ``Reinforcement Learning: an introduction''

Antonio Gulli and Amita Kapoor, ``Deep Learning with Tensorflow 2 and Keras''

Other references will be given during the lectures.

Main objectives of the course
Students will be conversant with the following aspects at the end of the course
1) Different types of deep learning models
2) Metrics for evaluation of the performance of the deep learning models
3) Create and evaluate deep learning models for various tasks

CO-PO Mapping

COs	Description	PO1	PO2	PO3	PO4	PO5	PO6

CO1	Be able to design, train, deploy neural networks for solving different practical/engineering problems and analyse & report its efficacy	3	3	3	3	2	1
CO2	Have a good level of knowledge (Conceptual &Mathematical) on different neural network settings to pursue research in this field	3	3	2	2	3	1
CO3	Build skills in using established ML tools/libraries and in building self-learning skills in the field	3	3	3	3	2	2

Evaluation pattern

The course carries four credits. The evaluation pattern is given below:

3 assignments – 30 points. The assignments are designed to test the student's understanding of the materials. These are both theoretical and problem oriented so that the student can assess his own abilities in handling the different aspects of the course.

1 project – 30 points.

1 mid-term written examination – 10 points

1 final project presentation – 30 points. Project presentation will be based on the project that the students have chosen.

Importance of the course:

The course focusses on the underlying essential skills needed both for research and industry in deep learning area. Students need to be trained in deep learning skills as it is one of the most used and sought skills in the industry. In this course, we focus on the basics of deep learning so that the students acquire skills that are actively sought by companies across India. Students who complete this course would be gaining vital skills that will stand them in good stead, both in research and industry.

………………………..